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Original Article

Influence of Whitening Toothpaste on Color, Roughness, and Microhardness of Composite Resins

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Abstract

Aims: This study aimed to evaluate color stability (ΔE), surface roughness (Ra), and Knoop microhardness (KHN) of composite resins under simulated toothbrushing with whitening toothpastes and desensitizing toothpaste. **Methodology:** One hundred disks were made with composite resins: Filtek Z350 XT (3M/ESPE) and Grandio SO (VOCO) and divided into five subgroups: AS (Control I) - immersed in artificial saliva; CS (Control II) - immersed in coffee solution; LW - brushing with Colgate Luminous White; OD – brushing with Oral-B 3D White; and SP - brushing with Sensodyne Total Protection, as control. The LW, OD, and SP groups had the disks brushed daily with 120 cycles after immersion in coffee solution (10 min) for a period of 30 days. ΔE, Ra, and KHN were obtained at baseline and after the treatments. Data were analyzed by ANOVA and Tukey's tests ($P < 0.05$). Student's *t*-test and Bonferroni test were performed to compare variables. **Results:** ANOVA revealed significant differences for ΔE, Ra, and KHN. ΔE: the highest ΔE mean values for Filtek were presented by SP group. For Grandio, the highest values were presented by SP and CS. Ra: Both composite resins presented similar behavior, with the highest mean values for groups AS and CS. KHN: The groups OD and SP made the most alteration on the surface, reducing the KHN values. **Conclusions:** Whitening toothpaste and immersion in coffee influenced on color stability, surface roughness, and microhardness of composite resins.

Keywords: Color, composite resins, hardness, roughness, whitening toothpastes

Introduction

The demand for esthetic dentistry is constantly increasing due to patients' search for esthetically attractive healthy smiles. The desire for whiter and brighter smiles has led to the improvement of dental products, especially whitening agents and composite resin.

Whitening toothpastes aim to remove the extrinsic stains and therefore, optimize tooth color. The whitening effect of these toothpastes relies on incorporated abrasive particles that remove the acquired pellicle and reduce extrinsic stains on tooth surface.[1,2] Notwithstanding, these abrasive particles are different in roughness, size, and shape, what consequently promotes different effects, depending also on the pressure used during toothbrushing.[2,3] Moreover, the high concentration of abrasive particles into the whitening toothpastes may increase the wear of tooth surface and roughness of the enamel surface.[3]

Therefore, attention should be paid on the abrasive effect of these toothpastes on esthetic composite resin restorations; material routinely used in dental clinic to mimic tooth's natural features such as color, translucence, and texture. The abrasion effect of daily toothbrushing may alter the material surface, affect shape and color, and favor plaque retention due to roughness on the restoration surface.[4]

Surface roughness is a parameter of high clinical relevance to evaluate wears' resistance, plaque accumulation, and gingival inflammation.[5] The increase in roughness is directly related to plaque accumulation, a determining fact on restoration color alteration.[6] The rationale behind this assumption is that increase in surface porosity, in loss of material mass caused by toothbrushing, and in water absorption favor color change.[7]

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In the long term, alterations on composite resin surfaces depend on intrinsic and extrinsic factors to which they are routinely exposed: insufficient curing, water sorption, and color alteration due to diet and intake of staining foods.[8] Previous studies also correlate the size and distribution of composite resin filler particles to the factors that interfere on material discoloration. The degree of water sorption and the hydrophilic property of the resin matrix also have an influence on the composite resin discoloration.[9] Substances present on food and beverages may also degrade the surface of restorative materials,[10] by affecting the organic phase of the resin matrix and disintegrating the disperse phase, altering surface roughness of the composite resin.[11]

Based on the aforementioned information, the literature lacks studies on the profile of the available nanoparticle-reinforced composite resins when submitted to the abrasive effect of whitening toothpastes. To compare these effects that could be promote by the whitening toothpaste, the present study chose a toothpaste with large abrasive particles in the composition, such as desensitizing toothpaste, to observe surface changes in nanoparticle-reinforced resins.

Thus, this study aimed to evaluate color stability (ΔE), surface roughness (Ra), and Knoop microhardness (KHN) of composite resins under simulated toothbrushing with different whitening toothpastes and a desensitizing toothpaste. The null hypotheses tested were the following: (I) the ΔE of the composite resins will not be modified by simulated toothbrushing with whitening toothpastes; (II) the Ra of the composite resins will not be modified by simulated toothbrushing with whitening toothpastes; and (III) the KHN of the composite resins will not be modified by simulated toothbrushing with whitening toothpastes.

Methodology

Specimen preparation

Fifty samples (2 mm height and 3 mm diameter) from each composite resin brand (shade A2) were fabricated [Table 1]. The composite resin was inserted in a 2 mm increment. A polyester matrix was placed over the composite resin and pressed with 200 g weight, and a glass slide to provide smooth, compact, standardized specimens. The composites' increments were cured on the top surface using LED Photocuring Unit (Emitter A Schuster, Rio Grande do Sul, Brazil), at 750 mW/cm^2 power density, activated for 40 s. To identify the surface to be submitted to treatment, a line was drawn with the aid of a blade on the opposite surface. The specimens were stored individually (Eppendorf, São Paulo, SP, Brazil) in artificial saliva[12] for 24 h, at 37°C.

Then, the specimens were polished using a sequence of 2400–4000 Grit Aluminum Oxide Abrasive Disks (Extec Corp., Enfield, CT, USA), for 10 s, in a polishing machine (DP-10, Panambra – São Paulo, SP, Brazil). After polishing, all specimens were stored in artificial saliva at 37°C for 24 h.

The specimens of each composite resin were randomly divided into five subgroups (n = 10):

- AS (Control I) – Stored in artificial saliva[12] at 37°C, during the entire period of study
- CS (Control II) – Immersion in coffee daily, for 10 min, without simulated toothbrushing
- LW – Daily toothbrushing cycles with the whitening toothpaste Colgate Luminous White™ (Colgate-Palmolive Industrial Ltd., São Bernardo do Campos, SP, Brazil), after 10 min of immersion in coffee, under agitation, during 30 days
- OD – Daily toothbrushing cycles with the whitening toothpaste Oral-B 3D White™ (Procter and Gamble do Brasil S/A, SP, Brazil), after 10 min of immersion in coffee under agitation, during 30 days
- SP – Daily toothbrushing cycles with control toothpaste Sensodyne Total Protection™ (GlaxoSmithKline Brasil Ltda., RJ, Brazil), after 10 min of immersion in coffee under agitation, during 30 days.

Color stability (ΔE)

The sample was assessed under standardized environmental conditions according to the Commission International de l'Eclariage (CIE) L*a*b* system, using a spectrophotometer (CM2600d, Konida Minolta, Osaka, Japan). The device was adjusted to a small area view, and the observer angle was set at 2°. The D65 standard light source with the reflectance mode and the 100% ultraviolet was included.[13]

The results of the color alteration were quantified in terms of three coordinates values (L*a*b*) as established by CIE system, which L* axis represents the degree of lightness and ranges from 0 (black) to 100 (white); the a* plane represents the degree of green/red color, whereas the b* plane represents the degree of blue/yellow color within the sample. The overall color change (ΔE) was calculated through the following formula: $\Delta E^*ab = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{0,5}$.

Surface roughness (Ra)

The mean surface roughness (Ra) was assessed through profilometer (Maxsurf XT 20, Mahr, Goettingen, Germany).

Table 1: Composite resins used

Composite	Batch number	Type	Composition	Filler content
Filtek Z350 XT (3M/ESPE)	N 330823BR	Nanoparticle	Bis-GMA, Bis-EMA UDMA, TEGDMA, PEGDMA, zirconia/silica	78.5% w/w
Grandio SO (VOCO)	13011320	Nanohybrid	Bis-GMA, Bis-EMA, BHT e TEGDMA	89% w/w

The diamond stylus moved at 2.5 mm long starting the first measurement 0.2 mm from the lower area of specimen, and a stylus speed of 0.1 mm/s. Three profile measurements were performed for each specimen at intervals of 0.25 mm, and a final average was used. Surface roughness measurement was performed at two periods: initial – 24 h after polishing; final – after surface treatments.

Knoop microhardness

The microhardness measurement was performed with a microhardness tester (FM-ARS 900, Future Tech Company, Tokyo, Japan), Knoop tip, under 50 g load for 15 s. Three indentations were performed at distances of 100, 200, and 300 µm on the surface of the specimens. The Knoop microhardness was measured at the following moments: initial – after polishing; final – after surface treatments.

Surface treatments

Before daily toothbrushing cycle, the specimens were immersed in 2 ml of coffee solution, at 37°C for 10 min, under constant agitation (Biomixer, TS-2000A VDRL Shaker). The coffee solution was prepared with 1 teaspoon of soluble coffee (Nescafé Original, Araras, São Paulo, Brazil) dissolved in 50 ml of boiled water.

After the period of immersion in coffee solution, specimen surface was submitted to 120 toothbrushing cycles with 200 g of weight, simulating three toothbrushing cycles with 40 cycles/day, which corresponds to three daily toothbrushing cycles in oral cavity for 1 month.[6]

The specimens were subjected to brushing abrasion in an automatic toothbrushing machine (Odeme Equipamentos Médicos e Odontológicos Ltd., Joaçaba, SC, Brazil), which imparted reciprocating motion to soft straight-bristle toothbrush (Sanifill Ultra profissional, Hypermarcas, São Paulo, Brazil) at 37°C. The abrasive slurry consisted of whitening toothpastes and artificial saliva, in a ratio of 1:3, by weight.[14] The whitening toothpastes used in this study are specified in Table 2.

Table 2: Whitening toothpastes used

Whitening toothpaste	Composition
Colgate Luminous White (Colgate-Palmolive India Ltd.)	Sodium fluoride (1100 ppm fluoride), water, hydrated silica, sorbitol, pentasodium triphosphate, tetrapotassium pyrophosphate, sodium lauryl sulfate, polyethylene, cocamidopropyl betaine, sodium saccharin, sodium hydroxide, titanium dioxide
Oral-B 3D White (Procter and Gamble GmbH)	Sodium fluoride (1450 ppm fluoride), water, hydrated silica, sorbitol, sodium lauryl sulfate, sodium hydroxide, sodium saccharin
Sensodyne Total Protection (GlaxoSmithKline)	Sodium fluoride (1400 ppm fluoride), 5% potassium nitrate, water, sorbitol, glycerin, cellulose gum, triclosan, silica, sodium lauryl sulfate, sodium saccharin, titanium dioxide, aroma

After the period of 30 consecutive days of surface treatment, the specimens were washed in deionized water and stored in artificial saliva at 37°C for 24 h.

Statistical analysis

Data were submitted to statistical analysis using Minitab (version 16.1, College State, PA, USA) and Statistica (version 9.1, Tulsa, OK, USA) software. The descriptive statistics consisted of the calculation of the means and standard deviations (SDs). To ΔE, inferential statistical analysis consisted of one-way ANOVA with a significance level of 5% ($P < 0.05$). Student's *t*-test and Bonferroni tests were applied to compare the variables. To KHN and Ra, inferential statistical consisted of two-way ANOVA followed by Tukey's test, with a significance level of 5% ($P < 0.05$).

Results

Color stability (ΔE)

One-way ANOVA showed statistically significant differences among treatments for the composite resin Filtek Z350 XT ($P = 0.0001$). According to Tukey's test, the lowest ΔE mean values for Filtek were presented by AS group (2.81 ± 1.91), whereas the highest mean value by SP group (14.85 ± 1.54). There was not a relevant difference between groups CS, LW, and OD [Table 3].

For Grandio, ANOVA showed statistically significant differences among the groups ($P = 0.0001$). The lowest values were exhibited by AS group (2.00 ± 1.26) and the highest by SP (11.22 ± 1.30) and CS (10.97 ± 1.71) groups. Groups LW and OD presented similar variations but differed from the other groups ($P < 0.05$) as shown in Table 3.

Table 4 presented the ΔE mean values for composite resin factor, according to Student's *t*-test, followed by Bonferroni test** ($\alpha = 0.05/k$). It is observed that the composite was statistically significant for the groups LW, OD, and SP.

Surface roughness (Ra)

According to two-way ANOVA, all factors showed statistically significant differences ($P < 0.05$) for surface roughness. Treatment ($P = 0.001$), composite resin ($P = 0.001$), and the interaction of factors ($P = 0.001$) were statistically significant.

Table 3: Means±standard deviation of ΔE and Tukey's test (5%) for the composite resins, according to treatments

Treatments	Grandio SO	Filtek Z350 XT
SP	11.22±1.30^{a}	14.85±1.54^{a}
CS	10.97±1.71^{a}	13.17±3.30^{a,b}
LW	6.04±1.91^{b}	12.22±1.98^{a,b}
OD	5.18±2.01^{b}	11.15±2.13^{b}
AS	2.00±1.26^{c}	2.81±1.91^{c}

Different letters means significant differences among groups ($P<0.05$)

Table 4: Results of Student's *t*-test and Bonferroni tests for the color stability (ΔE)

	Treatments				
	AS	CS	LW	OD	SP
Filtek Z350	2.81±1.91	13.17±3.30	12.22±1.98	11.15±2.13	14.85±1.54
Grandio SO	2.00±1.26	10.97±1.71	5.18±2.01	6.04±1.91	11.22±1.30
P-value*	0.285	0.085	0.001	0.001	0.001

*Bonferroni test (α=0.05/k), k: Comparison numbers

Table 5 showed the Ra means values (±SD) and Tukey's test. Regarding surface roughness, both composite resins presented similar behavior, with the highest mean values for groups AS and CS, and the lowest for LW, OD, and SP that were statistically different one from the other.

Knoop microhardness (KHN)

Two-way ANOVA showed that all factors exhibited statistically significant effect ($P < 0.05$) on Knoop microhardness. Treatment ($P = 0.001$), composite resin ($P = 0.001$), and the interaction of factors ($P = 0.001$) were statistically significant.

Table 6 showed the KHN means values (±SD) and Tukey's test. The highest Knoop microhardness values were seen for the composite resin Grandio SO. Treatment was statistically significant mainly for the OD and SP groups.

Discussion

Food and beverages contact teeth and restorative materials' surface simultaneously to saliva and before toothbrushing daily, in an active flow. Therefore, this current study differed from previous ones, in which specimens were immersed in solutions for a longer and continuous period of time, lacking this "out of contact" period. To simulate everyday oral habits, the surface treatments performed in this study consisted of cycles of immersion into coffee solution for 10 min; 120 toothbrushing cycles with whitening toothpastes, and storage in artificial saliva, to mimic the neutralizing saliva effect in the oral cavity, daily, for 30 consecutive days. This was an attempt to obtain data closer to the *in vivo* condition.

In the positive control group, the specimens were immersed in artificial saliva during the entire period of this study, and no surface treatments were performed. In this study, artificial saliva promoted a slight color alteration in the composite resins Filtek Z350 XT ($\Delta E = 2.81 \pm 1.91$) and Grandio SO ($\Delta E = 2.00 \pm 1.26$). However, ΔE values < 3.3 are considered values that represent clinically acceptable color alterations in dentistry.[15,16] These values were statistically different from the ones presented by the other groups and were the lowest ΔE values. The positive control group color alteration may be related to the long immersion period in artificial saliva to which the specimens were submitted. According to the studies of Domingos *et al*.,[17] immersion in artificial saliva significantly influenced the color stability of composite resin after 30 days.

On the other hand, in the negative control group, the specimens were immersed into coffee solution daily for 10 min but were not submitted to the toothbrushing cycles. Coffee is a standard staining solution used in laboratorial tests to evaluate color alterations of either teeth or dental materials because the population frequently consumes it. Coffee has a potential of staining tooth structure and composite materials[8] and can lead to significant alterations in the composite resin properties when used in high temperatures.[9,18] These findings corroborate with the literature,[9] regarding both composite resins: Filtek Z350 XT ($\Delta E = 13.17 \pm 3.30$) and Grandio SO ($\Delta E = 10.97 \pm 1.71$), for which, coffee promoted color alteration, thus presenting significant ΔE values concerning clinical conditions. Coffee influenced mostly the color of the nanoparticle-reinforced composite resins, regardless toothbrushing action on the surfaces.

The results of ΔE also showed significant differences among the treatments and the composite resins. Regarding the composite resins, the nanoparticle-reinforced composite resin Filtek Z350 XT exhibited higher ΔE values than the nanohybrid composite Grandio SO, in agreement with previous studies statements.[19] According to Heintze *et al*.,[6] this effect may be related to the composite resin composition: particle size, composition of resin matrix, and rate of conversion after polymerization.

After the surface treatments, both composites increased ΔE values, regardless of toothpaste used for the brushing cycles. This fact probably occurred due to the daily immersion of the specimens into coffee solution, as discussed above. Moreover, simulated toothbrushing may favor some alterations on the composite resin surfaces. Simulated toothbrushing *in vitro* is a parameter to evaluate the capacity of the restorative material to maintain smoothness, brightness, and avoid staining.[6]

Treatment with SP toothpaste exhibited the highest ΔE value, statistically different from LW and OD toothpastes. SP toothpaste is a desensitizing dentifrice with fluoride and triclosan in the composition, selected in the present study to be compared with the whitening toothpastes. SP toothpaste does not aim whitening the teeth, as LW and OD do. This toothpaste did not reduce significantly the color alteration promoted by coffee. Daily surface treatment, coffee immersion associated with toothbrushing with SP, significantly altered ΔE values.

When comparing the whitening toothpastes (LW and OD), we observed that they showed similar behavior regarding color alteration of the composites. The whitening effect of these toothpastes avoided the coffee extrinsic staining, becoming, therefore, a determining factor in decreasing the acquired color

Table 5: Means±standard deviation of roughness and Tukey's test (5%) for the toothpastes and times

Groups	Grandio SO	Filtek Z350 XT
AS		
Initial	0.38±0.47[e]	0.15±0.15[c]
Final	1.78±0.30[a]	1.59±0.69[a]
CS		
Initial	0.64±0.63[c,d,e]	0.15±0.15[c]
Final	1.55±0.53[a,b]	1.73±0.24[a]
LW		
Initial	0.99±0.44[b,c,d]	0.32±0.25[b,c]
Final	0.43±0.17[d,e]	0.81±0.54[b]
OD		
Initial	0.91±0.50[c,d,e]	0.60±0.30[b,c]
Final	0.42±0.22[d,e]	0.42±0.16[b,c]
SP		
Initial	1.08±0.41[b,c]	0.57±0.30[b,c]
Final	0.45±0.17[d,e]	0.51±0.31[b,c]

Different letters means significant differences among groups (P<0.05)

Table 6: Means±standard deviation of Knoop microhardness and Tukey's test (5%) for the toothpastes and times

Groups	Grandio SO	Filtek Z 350 XT
AS		
Initial	120.46±17.29[a]	82.63±9.27[a,b]
Final	124.55±11.36[a]	90.81±6.04[a]
CS		
Initial	119.39±23.15[a]	73.28±3.98[b,c,d]
Final	115.89±17.78[a,b]	68.66±11.81[b,c,d]
LW		
Initial	121.91±17.67[a]	67.15±14.34[c,d]
Final	104.34±35.63[a,b]	75.39±13.01[b,c]
OD		
Initial	130.16±27.42[a]	65.97±12.06[c,d]
Final	129.54±16.48[a]	59.56±10.39[d]
SP		
Initial	121.20±9.76[a]	75.88±7.73[b,c]
Final	87.99±19.54[b]	72.88±9.19[b,c,d]

Different letters means significant differences among groups (P<0.05)

alteration. In general, whitening toothpastes are specifically formulated to remove and prevent extrinsic staining, and the abrasives present in the composition are the main components that account for the whitening action of the toothpastes.[1]

The whitening toothpastes used in this study have abrasive and chemical agents such as pyrophosphate and hydrated silica in the composition. Pyrophosphate has the ability of dissolving extrinsic staining, while hydrated silica cleans the surface and has a greater capacity of removing stains than the other abrasive agents.[1,20] This study presented significant ΔE values for the LW and OD whitening toothpastes, showing that they promote an effective prevention of extrinsic stains on composite resin surfaces compared to the desensitizing toothpaste evaluated. Therefore, similar to other study,[20] these toothpastes seem to help removing superficial stains, but they do not have a whitening effect on the resin. Thereby, the first null hypothesis was rejected.

Moreover, the abrasiveness of the evaluated toothpastes was another variable that affected the surface of the composite resins. Previous studies showed the influence of toothbrushing amount of time on the degradation of composite resins leading to surface roughness, material weariness, and lower brightness according to the number of cycles.[6] The mean surface roughness (Ra) was one of the parameters used by authors to assess the effect of simulated toothbrushing effect on the composite resin surface. The initial Ra values of the composite Grandio SO were higher than those of the composite Filtek Z350 XT. However, both composite resins showed similar behavior after the surface treatments in relation to Ra.

Only the positive and negative control groups had statistically significant higher Ra final values than the initial ones. This may have occurred due to the components of the artificial saliva and coffee and to the water sorption in the resin matrix, resulting in plasticization, softening, and hydrolysis; consequently increasing the susceptibility of the composite surface for alteration.[9,17,18]

After the simulated toothbrushing with three different toothpastes of different compositions and commercial brands, roughness mean values significantly decreased. These findings corroborate to the previous study,[11] showing reduction in surface roughness after simulated toothbrushing. The nanoparticle-reinforced composite resin Filtek Z350 XT, after toothbrushing with LW toothpaste, showed a difference in the topographic profile with an increase in the Ra values, with no significant differences in relation to the other toothpastes. For the nanohybrid composite resin Grandio SO, all three groups with simulated toothbrushing demonstrated a decrease in the Ra values, without significant differences among the toothpastes.

It must be emphasized that before surface treatments, the resin specimens were polished with sandpaper discs, which may have favored surface roughness of the specimens. After toothbrushing, the rough aspect may have disappeared partially due to the surface polishing caused probably by the action of abrasive agents of the toothpastes.[21] These differences may be correlated to the composition of each toothpaste and composite resin. This also makes the comparison of the results of this study with those of the literature difficult since there are variations in toothpaste slurry, type of toothbrush, hardness and stiffness of the brush bristles, and number of toothbrushing cycles.[22] Consequently, the second null hypothesis of this study was also rejected.

Surface hardness is a mechanical property related to the material's resistance to wear.[23] Generally, alterations in the hardness of composite resins occur within the first 7 days after exposure to chemical solutions.[24] In this study, the initial readings were performed after curing and another reading after the surface treatments within 30 days.

Similar to previous studies,[11] the present study showed a significant difference in Knoop hardness values (KHNs) according to the type of composite resin. The composite Grandio SO exhibited greater KHN means than the composite Filtek Z350 XT, both before and after the treatments were performed. This difference is related to the composition and content of particles of each material. The composite resin Grandio SO has nanohybrid particles and 89% of filler content, resulting in greater rigidity in structure. While the composite resin Z350 XT has nanoparticles of approximately 0.6 μm and 78.5% of filler content. The lower filler content of the composite Filtek Z350 XT may have favored the lowest KHN means compared to the nanohybrid composite.

No statistically significant differences were noted, along the time of the study, for both composite resins when stored in artificial saliva, with no simulated toothbrushing. However, after immersion in coffee solution, KHN mean values slightly reduced. Although some studies analyze separately the effects of immersion into liquids, mimicking food intake, and brushing, the evaluation of such association is clinically relevant. In a clinical situation, the consumption of food or beverages occurs before oral hygiene habits. According to previous studies, the longer immersion in coffee solution at high temperatures may cause the reduction in Knoop hardness.[18] This immersion may provoke alterations in the resin matrix, resulting in exposure of the filler particles,[25] and alterations in the mechanical property on the resin surface, similar to the findings of the present study.

Associated to toothbrushing, groups OD and SP exhibited the same surface microhardness profile for the composite resins used, with reduction of mean values. However, group LW showed a different profile according to the type of composite resin. The nanoparticle-reinforced composite Filtek Z350 XT exhibited higher surface microhardness values, while the nanohybrid composite Grandio SO showed a reduction in KHN values. As the samples were submitted to daily immersion into coffee solution followed by simulated toothbrushing, the type of the dentifrice resulted in different surface wears, depending on the composite resin. Then, the third null hypothesis was rejected.

Thus, considering clinical situations, the association of daily coffee intake and toothbrushing may alter the nanoparticle-reinforced restorative materials, by changing its color and surface roughness and microhardness. Furthermore, this association depends on the toothpaste and composite resin composition. This study showed that for daily coffee intake customers, whitening toothpaste might be a choice, if the patient is well assisted by his dentist. Further studies are necessary to verify the effect of whitening toothpastes on esthetic composite resin restorations placed in the oral cavity.

Conclusion

Based on the results of this study, it can be concluded that color staining was higher in the composite resin group immersed in the coffee solution and in the group treated with the SP whitening toothpaste; surface roughness of the composite resins reduced after the treatments with whitening toothpastes; surface microhardness of the composite resins decreased when immersed into coffee solution and after the treatments with whitening toothpastes. The differences of the color, microhardness, and roughness values were dependent on the type of composite resin and toothpaste used.

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Conflicts of interest

There are no conflicts of interest.

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